parent filler (e.g., carbon black, pigment, or dye). Attached to one side of transparent cover **26** is an optical element such as a lens **30**. In the illustrated example of FIG. **2**A, lens **30** is formed by a replication technique and, together with optoelectronic device **22**, is present in an interior area **32** of module **20** (i.e., on the sensor-side of the transparent cover). Sidewalls **34** of transparent cover **26** also are covered by a non-transparent material **36**, which in the illustrated example of FIG. **2**A is composed of the same material as is used for spacer **28**. The exterior surface of substrate **24** includes one or more solder balls or other conductive contacts **38**, which can be coupled electrically to optoelectronic device **22** by way of conductive vias extending through substrate **24**.

In the example of FIG. **2**A, transparent cover **26** is substantially perpendicular to the module's optical axis and is substantially parallel to substrate **24**. In some implementations, however, transparent cover **26** can be tilted at an angle with respect to the plane of substrate **24**. Examples are illustrated in FIGS. **2**B, **2**C and **2**D. In each of these examples, sidewalls **34** of transparent cover **26** are covered by a non-transparent material **36**, which may be composed, for example, of the same material as is used for spacer **28**. In the implementation of FIG. **2**C, spacer **28** also is tilted at an angle with respect to the plane of substrate **24**.

In some cases, the non-transparent material **36** that covers the sidewalls **34** of transparent cover **26** is surrounded by another non-transparent material (e.g., a PCB material **40** such as FR4, which is a grade designation assigned to glass-reinforced epoxy laminate material). See module **20**A in FIG. **2**E. The glass-reinforced epoxy laminate material **40** also can be substantially non-transparent to light emitted by or detectable by optoelectronic device **22**.

In some implementations, the module includes alignment features **42** that extend beyond the object-side surface of the transparent cover **26** (see module **20**B in FIG. **2**F). Such alignment features **42** can facilitate positioning of the module within a smartphone or other appliance. The alignment features **42** can be composed, for example, of the same or a different non-transparent material as the spacer **28**. They can be attached to the spacer **28** by a section of non-transparent material that extends through the glass-reinforced epoxy laminate material **40**.

Some implementations include a projection **44** that extends beyond the top of the transparent cover **26** at or near its side edges, as shown in the module **20**C of FIG. **2**G. The projection **44**, which can be composed of a non-transparent material (e.g., a polymer such as epoxy with carbon black), can serve as a baffle to help guide light exiting or entering the module.

In some implementations, the optical element **30** is disposed on the sensor-side surface of the transparent cover **26**. In other implementations, the optical element **30** (e.g., a lens or diffuser) is disposed on the object-side surface of transparent cover **26** (see, e.g., FIG. **2**H) or optical elements can be disposed on both sides of the transparent cover.

The following paragraphs describe various fabrication techniques for manufacturing the foregoing optoelectronic modules and other similar modules that include a light emitting element (e.g., a LED, IR laser or VCSEL) or light detecting element (e.g., a photodiode) and an optical element such as a lens or diffuser integrated as part of the module. Some modules can include multiple optoelectronic devices (e.g., a light emitting element and a light detecting element). In some implementations, the modules are fabricated in a wafer-scale process so that multiple modules (e.g., hundreds or even thousands) can be manufactured at the same time. Some implementations include first mounting or attaching a transparent wafer onto UV dicing tape, then dicing the transparent wafer into singulated transparent covers. Further, in some implementations a coating (e.g. an optical filter) may be applied to a transparent wafer. The wafer subsequently can be mounted onto the UV dicing tape, and then diced into singulated transparent covers. Some implementations include using a vacuum injection technique to form various elements on a structured substrate (i.e., a substrate that has a non-flat or non-planar surface). Various elements (e.g., the optical elements or spacers) can be formed directly on one side or both sides of the transparent wafer using one or more vacuum injection and/or replication tools. Some implementations involve the placement of singulated transparent covers onto a support surface such as a carrier wafer, a vacuum chuck or UV dicing tape. The singulated transparent covers can have various shapes (e.g., circular, quadratic).

FIGS. **3**A-**3**E, for example, illustrate a wafer-level process for fabricating modules like the module **20** of FIG. **2**A. A replication and vacuum injection tool **50** having optical element replication sections **58** and spacer sections **60** is used to form a wafer-scale spacer/optics structure **72** that includes replicated optical elements **62** and vacuum injected spacers **64** (see FIG. **3**C). In particular, as shown in FIG. **3**A, singulated transparent substrates **66**, on which the optical elements (e.g., lenses) are to be formed, are placed on a support surface **68**. The support surface **68** can be implemented, for example, as a carrier wafer which rests on polydimethylsiloxane ("PDMS") vacuum sealing chuck **70**. Alternatively, the vacuum sealing chuck **70** itself can serve as the support surface. In some implementations, the support surface **68** may be implemented as a transient substrate (e.g., UV dicing tape, a PDMS, glass, polymer wafer, the tool(s) used to form the replicated optical elements **62** and/or the spacers **64**, or a combination of any of the foregoing examples). Singulated substrates **66** can be composed, for example, of a transparent material such as glass or a transparent plastic or polymer material.

As used in this disclosure, replication refers to a technique in which a structured surface is embossed into a liquid, viscous or plastically deformable material, and then the material is hardened, e.g., by curing using ultraviolet radiation or heating. In this way, a replica of the structured surface is obtained. Suitable materials for replication are, for example, hardenable (e.g., curable) polymer materials or other replication materials, i.e. materials which are transformable in a hardening or solidification step (e.g., a curing step) from a liquid, viscous or plastically deformable state into a solid state. As shown, for example, in FIG. **3**A, a replication material (e.g., a liquid, viscous or plastically deformable material) is placed onto the optical replication sections **58** of the replication and vacuum injection tool **50** (FIG. **3**A), and the replication sections **58** are brought into contact with the singulated transparent substrates **66** so that the replication material is pressed between the upper surfaces of the singulated transparent substrates **66** and the optical replication sections **58**. The replication material then is hardened (e.g., by UV or thermal curing) to form replicated optical elements **62** (e.g., lenses) on the surface of the singulated transparent substrates **66**.

Next, a vacuum injection material (e.g., a liquid, viscous or plastically deformable material) is injected through an inlet of the vacuum sealing chuck **70** so as to substantially fill spacer sections **60** and form the spacer elements **64** (see FIG. **3**B). At the same time, the spaces between the transparent substrates **66** are filled such that the sidewalls of the